



ROCKWELL INTERNATIONAL
NORTH AMERICAN SPACE OPERATIONS
ROCKY FLATS PLANT

Remedial Investigation Report For 903 Pad, Mound, and East Trenches Areas

Volume IV

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**Rocky Flats Plant
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ADMIN RECORD

60 SURFACE WATER

South Walnut Creek and Woman Creek are the two drainages at the Rocky Flats Plant that are downstream of the 903 Pad Mound and East Trenches area (Plate 6 1) A series of retention ponds known as the B series ponds is located on South Walnut Creek Two ponds designated C 1 and C 2 are located on Woman Creek Aside from the main creeks within these drainages the Central Avenue Ditch and the South Interceptor Ditch are located in the South Walnut Creek and Woman Creek drainages respectively For this investigation surface water sampling stations were established on the upper reaches of South Walnut Creek just upstream of the B series ponds along the South Interceptor Ditch and Woman Creek near pond C 2 and at seeps and springs located southeast of the 903 Pad Area and north of the Mound Area The B series ponds were not sampled for this investigation as they are scheduled for subsequent investigation as low priority sites in 1988 Discussion of the chemistry of the B and C series ponds as well as discussion of surface water flow within the respective drainages is based on historical information

61 SURFACE WATER HYDROLOGY

611 South Walnut Creek

As shown on Plate 6 1 five retention ponds designated B 1 B 2 B 3 B 4 and B 5 are located along South Walnut Creek to retain surface water runoff and plant discharges for monitoring and evaluation before downstream release of these waters Ponds B 1 and B 2 are reserved for spill control surface water runoff or treated sanitary waste of questionable quality and pond B 3 is a holding pond for sanitary

sewage treatment plant effluent (treated sanitary wastewater was also discharged to South Walnut Creek in the past however this practice was discontinued in 1979) Ponds B 4 and B 5 receive surface water runoff from the central portion of the plant and occasional discharges from pond B 3 The normal discharge of pond B 3 is to a spray system located in the vicinity of the East Trenches The surface water runoff received by pond B 4 is collected by the Central Avenue Ditch and upper reaches of South Walnut Creek Pond B 5 discharges to South Walnut Creek in accordance with the Plant's National Pollutant Discharge Elimination System (NPDES) permit (discharge point 006) South Walnut Creek joins North Walnut Creek and an unnamed tributary within the buffer zone before flowing into Great Western Reservoir located approximately one mile east of this confluence

Surface water flows along reaches of South Walnut Creek were not measured during this investigation however aside from localized downstream runoff all flow downstream of pond B 5 originates from pond B 5 and is measured and monitored for quality in accordance with the Plant's NPDES permit During surface water sampling for this investigation (July 24 1987) flow in the upper reach of South Walnut Creek west of Building 991 was visually estimated at approximately 5 gallons per minute (gpm) This flow is routed beneath Building 991 by a corrugated metal pipe Flow visually estimated at approximately 1 gpm occurs in a ditch south of Building 991 This flow appears to represent ground water seepage from the hill due south This seepage flows into South Walnut Creek via a concrete pipe and continues with the upper reach South Walnut Creek flow discharging from the corrugated metal pipe This confluence is located due north of the Mound Area

612 Woman Creek

Woman Creek is located south of the Plant and is isolated from surface water runoff from the Plant by the South Interceptor Ditch located due north of the creek. The two C series ponds C 1 and C 2 are located along Woman Creek south and east of the Plant respectively. Pond C 1 receives stream flow from Woman Creek. The discharge from pond C 1 is diverted around pond C 2 into the Woman Creek channel downstream. Pond C 2 is offset from Woman Creek and receives surface runoff from the South Interceptor Ditch that runs along the southern portion of the Plant. Water in pond C 2 is discharged to Woman Creek in accordance with the Plant NPDES permit (discharge point 007).

Flow in Woman Creek and the South Interceptor Ditch is intermittent in nature, appearing and disappearing along various reaches. During the 1986 Phase 2 initial site characterization, measurable flow occurred at less than one half of the ten stations located along Woman Creek and the South Interceptor Ditch (Rockwell International 1986a). All recorded flows were less than 10 gpm. During the 1986 and current investigation, there was no surface flow in Woman Creek downstream of pond C 2. The intermittent surface water flow behavior observed for Woman Creek and the South Interceptor Ditch is indicative of frequent interaction with the shallow ground water system.

62 SURFACE WATER CHEMISTRY

A discussion of surface water chemistry for the 903 Pad Mound and East Trenches Areas is also one of ground water chemistry as most of the surface water

samples collected for this investigation are from seeps that represent the surfacing of ground water and there is frequent interaction of surface water and ground water in the drainages. The seeps are ponded water and/or springs (some observable flow) located downslope and southeast of the 903 Pad Area or located downslope and north of the Mound area. Surface water flowing in drainages was sampled at stations on the South Interceptor Ditch and Woman Creek just upstream of Pond C 2 and at stations upstream of the B series ponds on South Walnut Creek. The B series ponds were not sampled for this investigation as they will be subsequently investigated as low priority sites in 1988. Discussion of the chemistry of the B series ponds is based on information gathered during the 1986 Phase 2 initial site characterization and data collected as part of the Plant's NPDES monitoring program (Pond B 5). Discussion of the chemistry of the C series ponds, Woman Creek and the South Interceptor Ditch is largely based on the 1986 investigation and NPDES monitoring data (Pond C 2) supplemented with data collected for this investigation and the 881 Hillside Area remedial investigation. All surface water stations are shown on Plate 6.1. Analytical data are presented in Tables 6.1, 6.2, 6.3 and 6.4. Samples were collected for this investigation on July 24, 1987 and were analyzed for the same parameters as ground water. Surface water samples including seeps and springs were not filtered prior to analysis.

6.2.1 Background Surface Water Chemistry

Background surface water chemistry is difficult to characterize because surface water chemistry is likely to be naturally variable even within one drainage due to frequent interaction of surface water flow and alluvial ground water. In order to facilitate discussion of surface water chemistry particularly inorganic

TABLE 6 1
VOLATILE ORGANIC CONCENTRATIONS IN SURFACE WATER*

Station	1 1 DCE	t 1 2 DCE	CHC13	1 2 DCA	1 1 1 TCA	CCL ₄	TCE	1 1 2 TCA	PCE
SW 50	140	<4	84	<4	<4	1005	40	<4	65
SW 51	101	<4	<4	<4	<4	282	17	<4	44
SW 52	73	<4	<4	<4	<4	<4	<4	<4	<4
SW 57	48	<4	<4	<4	<4	<4	<4	<4	<4
SW 58	<4	<4	<4	<4	<4	<4	<4	<4	<4
SW 55	50	<4	<4	<4	<4	<4	<4	<4	<4
SW 53	<4	<4	<4	<4	<4	<4	<4	<4	<4
SW 64	<4	<4	<4	<4	<4	<4	20	<4	<4
SW 63	<4	4	<4	<4	4	4	4	<4	4
SW 62	4	<4	<4	<4	<4	<4	<4	<4	<4
SW 27	4	<4	<4	<4	<4	<4	<4	<4	<4
SW 28	<4	<4	<4	<4	<4	<4	<4	<4	<4
SW 56	143	4	<4	<4	<4	<4	50	<4	72
SW 61	<4	<4	<4	<4	33	<4	6	<4	<4
SW 60	<4	<4	<4	<4	<4	173	<4	<4	<4
SW 59	133	<4	40	<4	<4	605	62	<4	60

Units (ug/l)

TABLE 6 2
RADIONUCLIDE CONCENTRATIONS IN SURFACE WATER*

Station	Gross Alpha	Gross Beta	Plutonium	Americium	U 234	U 235	U 238	Tritium
SW 50	26(14)	19(49)	55(7)	0(27)	1 3(1 5)	22(57)	6(1 1)	<110
SW 51	58(4)	28(8)	13(3)	0(11)	1 2(1 3)	30(91)	1 7(1 1)	<110
SW 52	114(10)	46(15)	5 4(1 5)	2(1 5)	1 0(1 4)	17(66)	6(1 8)	<110
SW 57	259(8)	63(20)	54(7)	0(2)	2 8(1 5)	57(68)	9(1)	<110
SW 58	24(21)	11(32)	8 9(2 1)	3(1 4)	1 0(8)	08(30)	1 3(8)	<110
SW 55	3(12)	42(28)	3 2(1 7)	0(3 2)	7(1 3)	0(26)	2 7(1 7)	<110
SW 53	203(48)	42(55)	25(5)	0(1 9)	1 4(1 1)	0(57)	2 4(1 3)	<110
SW 64	34(7)	93(16)	1(1 2)	01(1 3)	6 3(1 6)	0(38)	4 9(1 3)	<110
SW 63								
SW 62	60(20)	100(13)	1 3(9)	0(1 3)	3 2(2 9)	0(2 1)	5 1(3 0)	<110
SW 27	10(0)	61(3)	0(1)	0(1 6)	79(92)	17(52)	3 8(1 7)	<110
SW 28	2(17)	80(19)	1(1 2)	0(4 1)	13(79)	0(57)	1 6(1 3)	<110
SW 56	8(10)	18(6)	0(89)	0(2 0)	0(65)	19(53)	3 2(1 3)	<110
SW 61	11(12)	41(14)	0(82)	0(1 2)	85(84)	21(40)	93(75)	<110
SW 60	8(18)	33(24)	0(1 1)	0(1 2)	1 7(1 0)	37(44)	2 2(8)	<110
SW 59	26(6)	28(6)	0(93)	03(1 4)	3 1(1 2)	01(45)	5 6(1 4)	<110

Units (pCi/l) Parentheses indicate the 2 standard deviation counting error

TABLE 6 3

METAL CONCENTRATIONS IN SURFACE WATER *

Station	Ba	Cr	Co	Cu	Fe	Mn	Hg	Ni	Sr	Zn
SW 50	26	< 01	< 05	< 025	< 1	49	<	< 04	43	< 02
SW 51	21	< 01	< 05	< 025	< 1	< 015	<	< 04	40	< 02
SW 52	< 20	< 01	< 05	< 025	< 1	30	<	< 04	49	< 02
SW 57	26	< 01	< 05	< 025	< 1	38	0004	< 04	79	< 02
SW 58	< 20	< 01	< 05	< 025	< 1	03	<	< 04	59	< 02
SW 55	24	< 01	< 05	< 025	< 1	02	<	< 04	73	14
SW 53	< 20	< 01	< 05	< 025	< 1	09	<	< 04	69	< 02
SW 64	< 20	< 01	< 05	< 025	< 1	< 015	< 0002	< 04	1 1	< 02
SW 63	20	02	05	< 025	1	39	< 0002	04	1 1	03
SW 62	< 20	< 01	< 05	< 025	< 1	016	< 0002	< 04	97	< 02
SW 27	< 20	< 01	< 05	< 025	< 1	15	< 0002	< 04	52	04
SW 28	< 20	< 03	< 05	027	23	14	< 0002	82	43	< 02
SW 56	22	< 01	275	< 025		23	<	< 04	67	27
SW 61	< 2	< 01	< 05	18		05	0003	< 04	< 2	05
SW 60	< 2	< 01	< 05	< 025		< 015	<	< 04	58	59
SW 59	< 2	< 01	< 05	< 025		< 015	<	< 04	73	31

The following metals were not detected Al (2U) Sb (05U) Ag (01U) Be (005U)
Cd (005U) Cs (2U) Pb (005U) Mo (04U) Se (005U) Tl (01U) V (05U) All
units are mg/l U signifies the detection limit

TABLE 6 4
MAJOR ION CONCENTRATIONS AND OTHER PARAMETERS FOR SURFACE WATER*

Station	Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Chloride	Sulfate	Nitrate	TDS	SS	Oil & Grease	Cr(VI)
SW 50	147	9 6	<1	9 5	261	59	21	4 2	510	7	2 6	<1
SW 51	103	7 9	<1	7 8	436	16 9	61	4 9	332	3	6	<1
SW 52	110	13 7	<1	48	297	26	73	< 2	461	2	2	<1
SW 57	157	21 9	2	20 7	436	24	21	1 2	522	5	12 3	<1
SW 58	114	13 8	<1	11 6	270	32	22	1 4	375	3		<1
SW 55	127	19 7	1 3	35 2	326	34	37	24	452	2	1 2	<1
SW 53	80	26 4	3 1	113 3	483	72	20	< 2	666	2		<1
SW 64	46	54 2	1 3	102 7	404	46	83	< 2	716	13	2	<1
SW 63	112	34 0	2 2	111 8	361	50	198	< 2	675	17	<1	<1
SW 62	68	29 6	1 9	99 4	346	44	132	< 2	625	7	2 5	<1
SW 27	79	16 1	3 8	49 8	237	34	69	3 2	426	2	2	<1
SW 28	66	15 7	2 0	55 0	237	35	60	< 2	402	8	3 5	<1
SW 56	137	21 1	1 9	60 5	346	54	72	4 1	577	4	5	<1
SW 61	30	5 0	3 0	17 9	83	12	31	25	156	8	<1	<1
SW 60	114	17 2	1 4	36 8	290	44	45	4 5	482	1	1 6	<1
SW 59	122	24 4	1 4	38 2	335	39	24	3 8	524	8	1	<1

All units are mg/l

chemistry and radionuclides reference will be made to Tables 5 6 and 6 5 which show respectively ranges of analyte concentrations found in background alluvial ground water and surface water west of the Plant Surface water analyte concentrations ranges are based on data collected during the 1986 Phase 2 initial site characterization for stations SW 42 and SW 05 on Woman Creek and Rock Creek respectively The basis for the background alluvial ground water ranges is discussed in Section 5 Because the surface water stations are at ground water seeps or are otherwise along a flowing drainage where interaction with alluvial ground water is not quantified an analyte concentration will be flagged as possibly indicating contamination only if it is greater than the maximum value specified for either background surface water or alluvial ground water

6 2 2 Seeps Southeast of 903 Pad Area

There are many seeps downslope to the southeast of the 903 Pad Surface water stations established at these seeps are designated SW 50 SW 51 SW 52 SW 55 SW 57 and SW 58 Station SW 50 is closest to the 903 Pad and SW 51 and SW 52 are due south and downslope of SW 50 SW 57 and SW 58 are located in a ditch along the road east of SW 50 Water in the ditch passes under the road south of these locations through a culvert The discharge of the culvert SW 55 was sampled and it is noted that although SW 57 SW 58 and SW 55 are physically connected seepage was only observed at SW 55 in October 1987 indicating that localized ground water seepage also contributes to the flow at SW 55

The data indicate that most seeps are contaminated with VOCs Water at SW 50 shows the highest level of contamination with 1 l DCE at 140 ug/l CHCl_3 at 84 ug/l CCl_4 at 1005 ug/l TCE at 40 ug/l and PCE at 65 ug/l Most of these VOCs

TABLE 6 5
ESTIMATED BACKGROUND SURFACE WATER CHEMISTRY

<u>PARAMETER</u>	<u>CONCENTRATION RANGE</u>	
<u>RADIONUCLIDES (pCi/l)</u>		
Plutonium	02(04)	01(06)
Americium	02(03)	06(04)
Uranium 233+234	13(09)	38(14)*
Uranium 238	06(06)	12(08)*
Uranium 235	NA*	
Tritium	20(220)	80(220)
Strontium 90	NA	
Cesium 137	NA	
<u>METALS (ug/l)</u>		
Aluminum	150	540
Antimony	ND	37
Arsenic	ND	
Barium	ND	
Beryllium	ND	59
Cadmium	ND	
Cesium	170	0 340
Chromium	ND	
Cobalt	ND	
Copper	ND	
Iron	130	135
Lead	ND	
Manganese	ND	13
Mercury	ND	0 5
Molybdenum	450	680
Nickel	43	82
Selenium	ND	8 8
Silver	ND	22
Strontium	ND	110
Thallium	ND	6
Vanadium	450	1200
Zinc	5	16
<u>OTHER ORGANICS (mg/l)</u>		
Calcium	6 6	22
Magnesium	1 1	5 2
Potassium	0 39	0 56
Sodium	4	13
Bicarbonate	11	23
Carbonate	23	64
Chloride	2	3 4
Cyanide	ND	0 0016
Phosphate	0 92	1 4
Sulfate	ND	
Nitrate	<5	

* Rocky Flats Plant raw water supply in 1986 had minimum maximum and average total uranium concentrations of 0 3(0 1) 2 4(0 3) and 1(0 05) pCi/l respectively

were present at concentrations an order of magnitude lower than that observed during the third quarter of 1987 for alluvial ground water at well 1 71 located in this vicinity This is likely due to volatilization as ground water contacts the air

Contaminant levels decrease downslope of SW 50 SW 51 south of SW 50 has the next highest level of VOC contamination with 1 1 DCE at 101 ug/l CCl_4 at 232 ug/l and TCE at 17 ug/l CHCl_3 was not detected in this sample or in any other sample from seeps in this area At SW 52 downslope and south of SW 51 the only VOC detected was 1 1 DCE at 73 ug/l VOC concentration trends suggest that a solvent plume within alluvial ground water is migrating to the south but the one time sampling of seeps in close proximity to each other does not provide sufficient data to fully support this conclusion especially noting the volatilization that occurs as ground water surfaces However the alluvial ground water flow from the 903 drum storage site is in this direction

Strontium and major ion concentrations are similar to that observed in the alluvial ground water at 1 71 and 2 71 Strontium was 0 43 mg/l 0 40 mg/l and 0 49 mg/l at stations SW 50 SW 51 and SW 52 respectively This is similar to that observed for well 1 71 during the third quarter of 1987 (0 52 mg/l) Calcium sodium chloride and sulfate concentrations appear to represent a mix of alluvial ground water at 1 71 and 2 71 Although the concentration of oil and grease progressively decreases downslope from SW 50 also suggesting a plume (possibly of lathe coolant) these concentrations are typical of those observed in seeps and surface water at all stations

As previously mentioned stations SW 57 SW 58 and SW 55 are physically interconnected and to an unknown extent flow from SW 57 (and SW 58) contribute to

the flow at SW 55 At SW 57 the station closest to the terrace where the 903 drum storage site is located the only VOC detected was 1,1 DCE at 48 ug/l VOCs were not detected at SW 58 but 1,1 DCE was detected at 50 ug/l at SW 55 The absence of VOCs at SW 58 is probably due to spatial variations of VOC concentrations in water exposed to the air Furthermore as previously stated SW 55 receives localized seepage and the physical connection of seeps SW 57 SW 58 and SW 55 is not well defined

As with other seeps to the southeast of the 903 Pad Area metals and major ion concentrations simply reflect that observed for alluvial ground water The oil and grease was at the highest observed concentration (12.3 mg/l) at SW 57 compared to the other surface water stations however there are insufficient data to interpret the significance of this finding

Plutonium concentrations were elevated above background in all of the seeps mentioned above The concentrations of plutonium ranged from 3.2(1.7) to 55(7) pCi/l The highest concentrations were to the north near the 903 drum storage site at SW 50 [55(7) pCi/l] and SW 57 [54(7) pCi/l] and decreased to the south to 3.2(1.7) pCi/l at SW 55 However elevated plutonium was not observed in the alluvial ground water during the second and third quarters of 1987 As these surface water samples were not filtered and the surface soil is known to be contaminated with plutonium (Section 4.0) these results simply reflect particulate plutonium in the water originating from the surface soils and thus are not indicative of radionuclides in surface water These seeps are not connected to other surface water bodies Other radionuclides were within estimated background levels for alluvial ground water

6 2 3 Seeps Northwest of Pond C 2

To the southeast of the 903 Pad Area are four seeps near the South Interceptor Ditch designated SW 53 SW 62 SW 63 and SW 64 The only VOC detected was TCE at 20 ug/l which occurred only at SW 64 TCE was not detected in the alluvial ground water in this vicinity (well 29 87) Plutonium appears slightly elevated relative to background at SW 53 (25 ± 5 pCi/l) and at SW 62 (13 ± 0.9 pCi/l) but not elevated at SW 64 (0.1 ± 1.2 pCi/l) (There are no radionuclide data for SW 63) As discussed above any plutonium contamination is presumed to be due to plutonium contaminated soil in the sample Other radionuclides were within estimated background levels Strontium concentrations were somewhat lower than that observed for alluvial ground water in this vicinity (well 29 87 2.7 mg/l) Strontium was present at 0.69 mg/l 0.97 mg/l 1.1 mg/l and 1.1 mg/l for stations SW 53 SW 62 SW 63 and SW 64 respectively Sodium was at concentrations of 113 mg/l 99 mg/l 112 mg/l and 102 mg/l at SW 53 SW 62 SW 63 and SW 64 respectively Sulfate occurred at 20 mg/l 132 mg/l 118 mg/l and 83 mg/l at these stations respectively This appears to simply reflect interaction with alluvial ground water as sodium and sulfate were 360 and 850 mg/l respectively at well 29 87

6 2 4 Woman Creek Drainage Near Pond C 2

Any impacts to surface water of the South Interceptor Ditch or Woman Creek from the 903 Pad Mound and East Trenches Areas would be reflected in the chemistry of the waters in the vicinity of ponds C 1 and C 2 as this location is hydraulically downgradient of these areas in terms of surface water runoff and components of alluvial ground water flow In this vicinity the South Interceptor

Ditch (SW 27) and Woman Creek (SW 28) were sampled and analyzed as part of this investigation. Other stations on Woman Creek (SW 29 downstream of Pond C 1 and SW 26 SW 2 and SW 1 all downstream of Pond C 2) and station SW 30 on the South Interceptor Ditch north of Pond C 1 were dry at the time of sampling in July 1987. Radiochemistry data collected by Rockwell from 1976 to 1986 are also discussed.

At SW 28 on Woman Creek VOCs were not detected, the nickel concentration was high, and major ions were elevated relative to background alluvial ground water and surface water. Nickel was 0.82 mg/l, a value ten times background with respect to alluvial ground water, and the alluvial ground water in this vicinity (wells 29 87 and 65 86) does not appear to be elevated in nickel. Nickel was not detected in 1986 at this station (Rockwell International 1986a) and the significance of this finding is unknown at this time. Strontium (0.43 mg/l) was approximately two times the concentrations observed at pond C 2 and SW 32 during 1986 but is typical of the alluvial ground water in this vicinity. Uranium 233+234 [0.13 (0.79)] and uranium 238 [1.6 (1.3)] concentrations were typical of those observed in 1986 at this station and pond C 1 and are somewhat higher than the concentrations observed relative to other upgradient stations on Woman Creek (1986) but are well within the range of background alluvial ground water. Other radionuclides were at background concentrations. The major cations calcium (66 mg/l), magnesium (15.7 mg/l), sodium (55 mg/l), chloride (35 mg/l), and sulfate (60 mg/l) are at concentrations typical of those observed at this station in 1986 and are somewhat elevated relative to concentrations observed at upgradient stations in 1986. However, the alluvial ground water in this vicinity (well 65 86) has somewhat higher concentrations of sodium, calcium, and sulfate which may simply reflect localized interaction with the ground water.

Historical radiochemistry data for Pond C 1 collected by Rockwell (Table 6 6) show average annual radionuclide concentrations at or near background levels. Occasionally elevated discrete concentrations of plutonium and americium were noted prior to 1980.

In general the South Interceptor Ditch at SW 27 has similar major ion chemistry relative to Woman Creek in this vicinity but has higher concentrations of uranium 238. Uranium 238 [5.8(1.7) pCi/l] is at a concentration typical of background alluvial ground water and local alluvial ground water. Strontium was at 0.32 mg/l, typical of the concentrations observed at this station and stations near the old landfill and 881 Hillside in 1986 but higher than at the most upgradient station (SW 37). Again both the strontium and uranium 238 concentrations probably reflect interaction with the alluvial ground water. VOCs were not detected at SW 27 and other radionuclides were at background levels.

Historical radiochemistry data for Pond C 2 (Table 6 7) show all radionuclide concentrations to be at or near background levels. These data are from 1981 through 1986.

6.2.5 Upper South Walnut Creek

At the Mound Area station SW 60 is a corrugated metal pipe discharging South Walnut Creek flow which originates to the west of SW 56. Station SW 56 is on a ditch that appears to be seepage from the base of the hill to the south. The ditch is not part of the main flow of South Walnut Creek as the creek is routed beneath this area.

TABLE 6 6
PLUTONIUM URANIUM AMERICIUM AND TRITIUM CONCENTRATIONS AT POND C 1+
(NUMBER OF SAMPLES)

RADIONUCLIDES

	YEAR (Number of Samples)										
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Plutonium	(51)	(51)	(52)		(53)	(37)	(50)	(51)	(52)	(51)	(44)
C _{MIN}	0 013	< 0 1	< 0 1		0 004+0 005	0 002+0 007	0 005+0 006	0 01+0 01	0 000+0 005	0 00+0 02	0 01+0 02
C _{MAX}	3 379	42 4	0 5		< 0 07	0 22+0 04	0 10+0 03	0 06+0 04	0 06+0 02	0 010+0 02	0 04+0 01
C _{AVG}	< 0 275	< 0 9	0 1		< 0 01	0 29+0 002	0 016+0 002	0 012+0 001	0 017+0 003	0 027+0 002	0 015+0 002
Uranium	(38)	(54)	(52)		(53)	(37)	(50)	(51)	(52)	(51)	(44)
C _{MIN}	0 473	< 0 1	0 2		< 0 1	0 7+0 06	0 1 0 05	0 05 0 07	0 2+0 1	0 14+0 09	0 0+0 1
C _{MAX}	2 801	4 0	7 9		< 11	6 5+0 2	8 4+0 8	5 3+0 4	7 4+0 3	6 5+0 8	4 6+0 4
C _{AVG}	1 191	0 7	2 5		30	2 23 0 03	2 0 0 2	1 66 0 03	2 00+0 04	2 84 0 05	1 30+0 03
Americium	(51)	(54)	(52)		(53)	(37)	(50)	(51)	(51)	(51)	(44)
C _{MIN}	0 003	0 1	< 0 1		0 001	0 01+0 02	0 02+0 03	0 05+0 02	0 01+0 04	0 04+0 06	0 02+0 03
C _{MAX}	1 012	0 5	0 2		0 16+0 08	0 05+0 02	0 09+0 09	0 05+0 03	0 08+0 04	0 08+0 02	0 10+0 06
C _{AVG}	< 0 103	< 0 1	< 0 1		< 0 07	0 004+0 002	0 02+0 002	0 004+0 003	0 008+0 003	0 011+0 002	0 004+0 003
Tritium	(58)	(52)	(52)		(53)	(37)	(50)	(51)	(47)	(49)	(41)
C _{MIN}	< 500	505	500		400	500 500	400+500	300+600	500+600	1000 1000	700+600
C _{MAX}	1893	1017	1000		120+600	900+500	1200+500	600+800	900+800	300+700	600+500
C _{AVG}	< 660	717	< 700		600	< 400	400+100	100+100	100+100	100+100	100+100

This value is suspect

Total uranium

+ Concentrations pCi/l

Ref Rockwell International 1977 1978 1979 1980 1981a 1982a 1983a 1984a 1985 1986g 1987a

TABLE 6 7
 PLUTONIUM URANIUM AMERICIUM AND TRITIUM CONCENTRATIONS AT POND C 2
 (NUMBER OF SAMPLES)

RADIONUCLIDES	YEAR										
	(Number of Samples)										
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Plutonium						(3)	(3)	(9)	(7)	(1)	(1)
C _{MIN}						0 03±0 03	0 00±0 02	0 00±0 02	0 05±0 04	0 05±0 03	0 0±0 0
C _{MAX}						0 05_0 02	0 09±0 05	0 06±0 03	0 11±0 07	0 05±0 03	0 0±0 0
C _{AVG}						0 04_0 02	0 05±0 02	0 03±0 01	0 04±0 02	0 05±0 03	0 0±0 0
Uranium						(3)	(3)	(9)	(7)	(1)	(1)
C _{MIN}						1 8±0 2	1 4±0 02	2 8±0 2	3 7±0 4	3 7±0 5	8±2
C _{MAX}						4 3±0 1	3 2±0 4	5 0±0 3	6 3±0 6	3 7±0 5	8±2
C _{AVG}						3 0_0 1	2 0_0 2	4 0_0 1	5 3±0 2	3 7±0 5	8±2
Americium						(3)	(3)	(9)	(7)	(1)	(1)
C _{MIN}						0 00±0 04	0 04±0 07	0 03_0 04	0 03±0 04	0 04±0 02	0 03±0 08
C _{MAX}						0 05_0 03	0 08±0 07	0 08±0 02	0 11±0 06	0 04±0 02	0 03±0 08
C _{AVG}						0 02±0 02	0 02±0 04	0 01±0 02	0 03±0 02	0 04±0 02	0 03±0 08
Tritium						(5)	(4)	(9)		(2)	(2)
C _{MIN}						500±500	100±600	200±500	100±400	0±600	100±400
C _{MAX}						400±600	500±600	500±500	300±400	300±700	300±400
C _{AVG}						200±200	300±300	200±200	0±200	200±500	100±300

Concentrations in pCi/l

Total uranium

Ref Rockwell International 1977 1978 1979 1980 1981a 1982a 1983a 1984a 1985 1986g 1987a

by the corrugated metal pipe. Water in the ditch eventually discharges to South Walnut Creek through a concrete pipe (SW 61). The flow in South Walnut Creek upstream of Pond B 4 is primarily the combined flow from the discharge of these pipes (SW 60 and SW 61). A spring located at the base of the hill to the south and downstream of SW 60 and SW 61 was also sampled.

The upper reach of South Walnut Creek as characterized by the discharge at SW 60 contains CCl_4 and above alluvial background ground water levels of strontium, zinc, and nitrates. CCl_4 was detected at 173 ug/l, strontium at 0.58 mg/l, zinc at 0.59 mg/l, and nitrate at 4.5 mg/l. Radionuclide concentrations were typical of background alluvial ground water and aside from zinc and strontium, other metals were at or near detection limits. The nitrates and major ion concentrations were typical of the alluvial ground water in the vicinity of the 903 Pad and Mound Areas. CCl_4 and elevated zinc were present in the alluvial ground water east of this reach of South Walnut Creek at well 17 87 (Mound Area); however, flow through this pipe originates inside the perimeter security zone (PSZ) so the Mound is not the source of this surface water contamination. The source has not been determined at this time.

As mentioned, the flow at SW 56 discharges downstream through a culvert at SW 61. At SW 56, 1,1-DCE was 143 ug/l, TCE was 50 ug/l, and PCE was 72 ug/l. At SW 61, these VOCs were absent except TCE at 6 ug/l and 1,1,1-TCA at 33 ug/l. At both locations, radionuclide concentrations were typical of background alluvial ground water. Strontium and zinc concentrations at SW 56 (0.67 mg/l and 0.27 mg/l, respectively) were typical of the alluvial ground water at the Mound Site (wells 17 74 and 17 87). The organic contaminants are also typical of those in alluvial ground water at the Mound Area. However, zinc and strontium were below or near detection limits at SW 61. (Copper was reported at 0.18 mg/l at SW 61 for reasons that are not

known at this time) It is clear when examining the major ion data that the flow at SW 61 must be diluted with low total dissolved solids (TDS) water because the major ion concentrations at SW 56 are generally three times that observed at SW 61 The source of this low TDS water has not yet been determined but it may be the source of the copper and 111 TCA detected at SW 61

As with the water at SW 60 and SW 56 the seep SW 59 located downstream of the confluence of SW 60 and SW 61 has nitrate and major ion concentrations similar to alluvial ground water of the Mound Area Radionuclides were at background concentrations and strontium and zinc occurred at 0.73 mg/l and 0.31 mg/l respectively Of note was the presence of high VOC concentrations 11 DCE was 133 ug/l CHCl_3 was 40 ug/l CCl_4 was 605 ug/l TCE was 62 ug/l and PCE was 60 ug/l Aside from the CCl_4 these organics are elevated in the alluvial ground water of the Mound Area CCl_4 has not been detected at well 174 and was present at a concentration of only 48 ug/l at well 1787 There may be a very localized source of CCl_4 at the Mound Area contributing to this contamination

6.2.6 B Series Ponds

As previously mentioned the B series ponds were not sampled as part of this investigation as they are targeted for subsequent investigation as low priority sites The following discussion is based on data collected for the 1986 Phase 2 initial site characterization and on historical data collected as part of NPDES monitoring

6261 Pond B 1

Pond B 1 is located northeast of the Mound Area and east of the sewage treatment plant. This pond is reserved for spill control surface water runoff or treated sanitary waste of questionable quality. Based on the 1986 data, pond B 1 water quality is characterized by major ion concentrations typical of the alluvial ground water in the area, somewhat elevated U 233+234 [6.4(0.6) pCi/l] and U 238 [9.6(0.9) pCi/l] and significantly elevated plutonium [4.2(0.6) pCi/l]. There are no metals with notably high concentrations and, with the exception of chloroethane (5.5 ug/l), HSL organics were not present above detection limits. Pond B 1 currently only receives runoff from the small drainage area surrounding it; however, historically the pond received low level radioactive waste. In 1973, the plutonium inventory of the sediments was 2.9 curies. Clearly, the elevated concentration of plutonium in the water is indicative of a high plutonium residual today.

6262 Pond B 2

Pond B 2 also currently receives runoff and historically received low level radioactive waste consisting of laundry water and cooling tower blow down. In contrast to the water quality of pond B 1, pond B 2 water quality has higher sodium and chloride concentrations and has alluvial background ground water levels of radionuclides, with the exception of slightly elevated plutonium [0.37(0.19) pCi/l] and americium [0.15(0.08) pCi/l]. Chloroethane was also present in pond B 2 at 79 ug/l.

6263 Pond B 3

Pond B 3 receives effluent from the sewage treatment plant. Water in pond B 3 is spray irrigated. HSL organics were not present above detection limits. Major ion concentrations were typical of those for pond B 1 and zinc (0.580 mg/l) was moderately elevated. The nitrate concentration was notably high at 13.4 mg/l.

6264 Pond B 4

Pond B 4 receives surface water runoff and occasional flow from pond B 3. Radionuclides were at alluvial background ground water levels. Nitrates were undetected and major ion concentrations were similar to pond B 1. Strontium and zinc occurred at 0.310 mg/l and 0.360 mg/l respectively. These concentrations are typical of alluvial ground water at the Mound Area. Methylene chloride and TCE were detected at 340 and 7 ug/l respectively.

Prior to the construction of pond B 5 in 1980, pond B 4 was used as a holding pond and water collected was monitored for radionuclides before it was discharged into South Walnut Creek. Historical radiochemistry data for pond B 4 collected by Rockwell indicates that plutonium and americium had at times exceeded background levels from 1976 through 1980. The data are shown in Table 6.8.

6265 Pond B 5

Pond B 5 was constructed in 1980 downgradient of Pond B 4. Pond B 5 receives storm water runoff from the central portion of the Plant site and is used for surface water control. Water collected in this pond is analyzed prior to controlled

TABLE 6 8
 PLUTONIUM URANIUM AMERICIUM AND TRITIUM CONCENTRATIONS AT POND B 4
 (NUMBER OF SAMPLES)

RADIONUCLIDES		YEAR						
		(Number of Samples)						
		1976	1977	1978	1979	1980	1981	1982
Plutonium	(51)	(54)	(52)	(53)	(53)	(53)	(53)	(53)
	C _{MIN}	08	< 01	< 1	01± 01	01± 01	01± 01	01± 01
	C _{MAX}	10 94	6 0	2 4	40± 02	40± 02	40± 02	40± 02
	C _{AVG}	2 161	<1 2	< 6	< 01	< 01	< 01	< 01
Uranium	(38)	(54)	(52)	(52)	(53)	(53)	(53)	(53)
	C _{MIN}	1 578	< 1	6	99± 03	99± 03	99± 03	99± 03
	C _{MAX}	4 505	4 0	17 9	15± 3	15± 3	15± 3	15± 3
	C _{AVG}	1 656	<1 2	5 8	< 7	< 7	< 7	< 7
Americium	(51)	(54)	(52)	(52)	(53)	(53)	(53)	(53)
	C _{MIN}	014	01	< 1	< 01	< 01	< 01	< 01
	C _{MAX}	3 244	5 9	5	22± 01	22± 01	22± 01	22± 01
	C _{AVG}	618	< 6	< 2	< 05	< 05	< 05	< 05
Tritium	(58)	(52)	(52)	(52)	(53)	(53)	(53)	(53)
	C _{MIN}	<500	516	<500	<400	<400	<400	<400
	C _{MAX}	2207	1525	1400	1100±700	1100±700	1100±700	1100±700
	C _{AVG}	887	848	<800	<600	<600	<600	<600

Concentrations in pCi/l

Total Uranium

Ref Rockwell International 1977 1978 1979 1980 1981a 1982a 1983a 1984a 1985 1986g 1987a

offsite discharge The NPDES monitoring program has included continuous collection and analyses of surface water samples (Pond B 5) from 1981 through 1986 Data for these samples are presented in Table 6 9

Based on the Rockwell monitoring data the highest concentration of plutonium was found in a sample collected in 1981 at 0 15(0 07) pCi/l All the other concentrations ranged from 0 5(0 03) pCi/l to 0 11(0 04) pCi/l However the average annual concentrations [range 0 013(0 007) to 0 04(0 02) pCi/l] during any year (1981 1986) were at or near background levels Americium concentrations ranged from 0 11(0 06) to 0 2(0 1) pCi/l however average annual concentrations [range 0 005(0 008) to 0 02(0 01) pCi/l] were at or near background levels The concentrations for uranium varied from 0 7(0 1) to 21(1) pCi/l however average annual concentrations during these years [range 3 5(0 1) to 6 9(0 3) pCi/l] were at or near background levels for alluvial ground water The average concentrations for tritium were also typical of background alluvial ground water The Phase I 1986 data show pond B 5 radionuclide concentrations all within background levels

6 2 7 South Walnut Creek at Indiana Street

During the 1986 Phase 2 initial site characterization surface water was flowing at station SW 3 located at Indiana Street on Walnut Creek Water quality data indicate that HSL organics were not present above detection limits and radionuclides were at concentrations characteristic of background conditions

TABLE 6 9
 PLUTONIUM URANIUM AMERICIUM AND TRITIUM CONCENTRATIONS AT POND B 5
 (NUMBER OF SAMPLES)

RADIONUCLIDES	YEAR										
	(Number of Samples)										
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Plutonium						(11)	(19)	(49)	(33)	(17)	(13)
C _{MIN}						00± 01	0 00± 0 2	0 5± 03	043± 006	02± 05	01± 02
C _{MAX}						15± 0 7	0 11± 0 4	11± 04	096± 002	05± 02	06± 02
C _{AVG}						04± 02	0 03± 0 1	019± 005	022± 005	013± 007	002± 006
Uranium						(11)	(19)	(49)	(33)	(17)	(13)
C _{MIN}						7± 1	1 3± 2	2 3± 3	2 7± 3	3 2± 3	2 9± 4
C _{MAX}						6 8± 2	9 4± 6	8 4± 6	21± 1	10± 1	13± 2
C _{AVG}						4 6± 1	3 5± 1	4 73± 05	6 2± 1	6 1± 2	6 9± 3
Americium							(19)	(49)	(33)	(17)	(13)
C _{MIN}						02± 02	03± 05	09± 06	11± 06	05± 05	03± 08
C _{MAX}						14± 05	08± 05	2± 2	160± 06	13± 06	2± 1
C _{AVG}						02± 01	02± 01	005± 008	02± 01	01± 01	02± 02
Tritium						(14)	(21)	(60)	(95)	(50)	(33)
C _{MIN}						0± 500	700± 500	90± 800	300± 400	500± 1100	500± 400
C _{MAX}						800± 400	1000± 600	700± 700	1100± 500	500± 900	1000± 600
C _{AVG}						400± 100	300± 100	100± 100	200± 100	200± 100	100± 100

Concentrations in pCi/l

* Total uranium

Ref Rockwell International 1977 1978 1979 1980 1981a 1982a 1983a 1984a 1985 1986g 1987a

63 SEDIMENTS

Sediment samples were collected during the 1986 Phase 2 initial site characterization from creeks and ditches that traverse the Rocky Flats Plant. Impacts of the 903 Pad Mound and East Trenches Areas on stream sediments would be reflected in the data collected for sediment stations SED 1 and SED 2 in the Woman Creek drainage and SED 11 SED 12 SED 13 and SED 3 in the South Walnut Creek drainage. Except for the presence of what appears to be laboratory introduced contamination (acetone and methylene chloride) HSL organics were not detected in these sediment samples. As radionuclides are the contaminants of greatest concern in terms of sediment transport potential radionuclide contamination of downgradient sediments is the focus of this discussion.

631 Woman Creek

Plutonium was the only radionuclide above background in the sediments at SED 1 and SED 2. The respective concentrations were 0.06(0.02) and 0.80(0.09) pCi/g. SED 2 is located on an ephemeral stream due north of Woman Creek which drains the East Trenches Areas. The elevated concentrations at SED 1 and SED 2 are similar to those reported for soils in this vicinity (Rockwell International 1987a) implying that these elevated plutonium concentrations are simply due to resuspension and settling of contaminated dust from the 903 Pad Area. Surface water stations at SED 1 (SW 1) and SED 2 (SW 2) were both dry at the time sediment samples were collected.

Woman Creek below the 881 Hillside ranges from 5 880 due south of SWMU 106 to
5 820 at Pond C 1

70 AIR

The 903 Pad Area is recognized as the principal source of airborne plutonium contamination at the Plant. This is as a result of the previous storage of drums containing plutonium contaminated cutting oil from machining operations. The 903 drum storage site was established in July 1958. Drums were first found to be leaking in 1959 and evidence of general drum deterioration and soil contamination was reported in 1964. Drum removal began in January 1967 and was completed by June 1968.

Several Plant site particulate samplers located immediately east, southeast, and northeast of the 903 Pad Mound and East Trenches Areas have historically shown the highest plutonium concentrations. As indicated by the 1986 Plant site wind rose presented in Figure 7.1, these samplers are immediately downwind of the 903 Pad Mound and East Trenches Areas based upon a review of the prevailing winds at the Plant site. This finding is corroborated by the results of soil surveys which indicate elevated plutonium concentrations to the east, particularly the southeast of the area.

Ambient air data analyzed for 1987 do not indicate any unusual effects due to field activities at the 903 Pad Mound and East Trenches Areas. An analysis of 1) particulate sampler data from stations near the 903 Pad Mound and East Trenches Areas and 2) real time volatile organics monitoring conducted during the summer 1987 field activities indicates that there were no significant releases of plutonium or volatile organics due to RI field activities. This is also verified by the absence of radioactive contamination of either personnel or equipment associated with 903 Pad Mound and East Trenches Areas field activities.

excellent coverage of the total size range of respirable particles as discussed in applicable EPA publications (EPA 1982 and 1985)

Figure 7 2 presents the location of the RAAMP samplers on and adjacent to the Rocky Flats Plant. Figure 7 3 shows the locations of off site community RAAMP samplers. Twenty three of these monitoring stations are located directly within or adjacent to the Plant security area (on site samplers). Exposed filters from these twenty three on site samplers are collected biweekly and analyzed individually for TLL alpha activity. The exposed filters from the remaining twenty eight sampler locations are collected bi weekly and are composited by location into monthly samples and the composites are sampled individually for plutonium.

Filters from five of the twenty three on site samplers have historically shown a higher level of plutonium than other on site RAAMP samplers. These include sampler locations S 5 S 6 S 7 S 8 and S 9. As indicated by Figure 7 1, each of these samplers can be directly impacted by potential emissions from the 903 Pad Mound and East Trenches Areas. In particular, samplers S 7 S 8 and S 9 are most likely to be impacted by soils disturbance activity in this area. Exposed filters from each of these five sampler locations are analyzed separately for plutonium on a biweekly basis.

The remaining eighteen on site samplers are collected biweekly and analyzed individually for TLL alpha activity. A Plant Screening Guide (PSG) of 0.01 picocuries per cubic meter (pCi/m^3) of TLL alpha activity has been established. The PSG is more conservative than the DOE derived concentration guide (DCG) for plutonium inhalation by members of the public of $0.02 \text{ pCi}/\text{m}^3$ of TLL alpha.

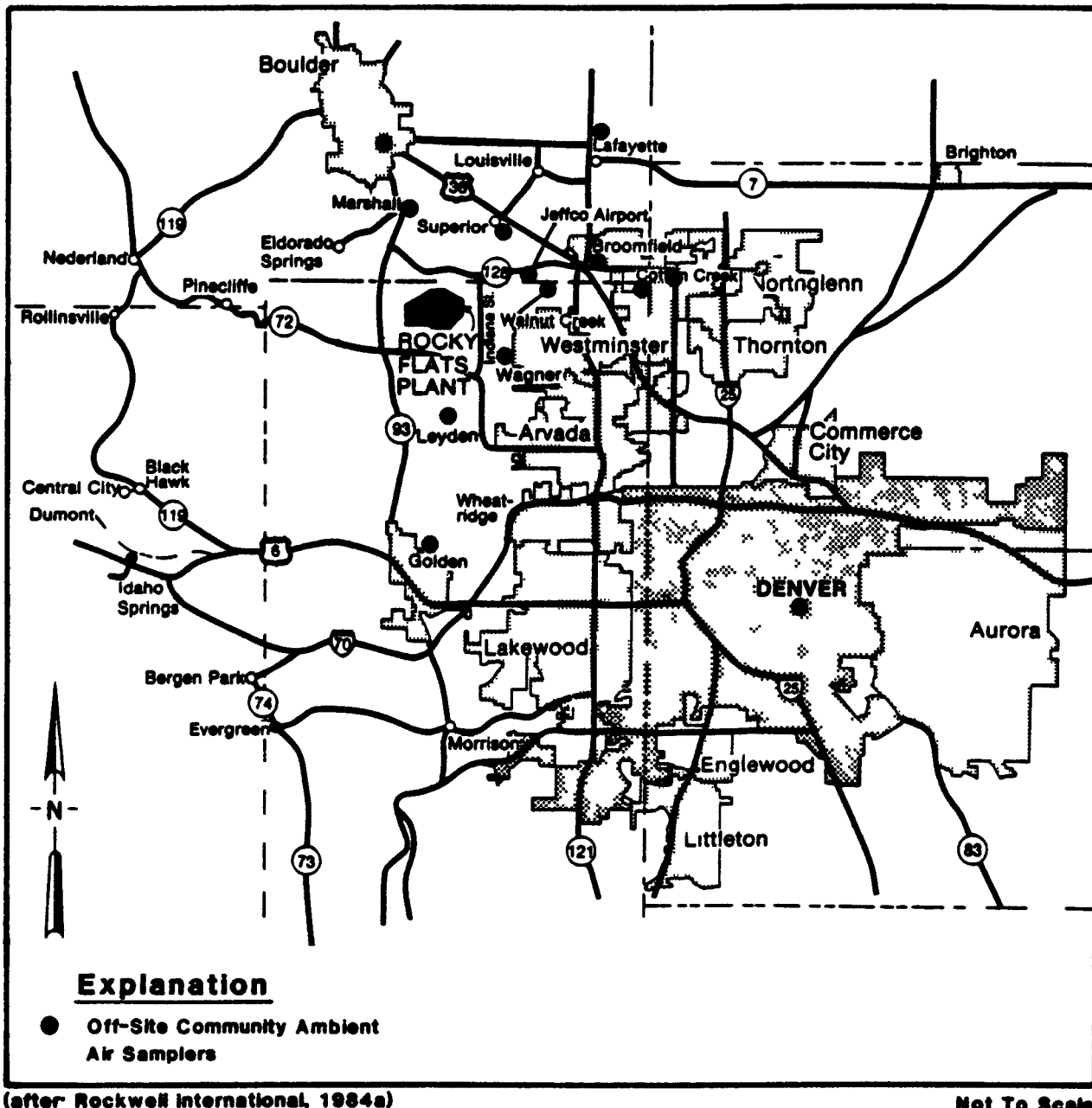


Figure 7-3
Location of Off-Site Community Ambient Air Samplers

Any of the exposed filters from these eighteen on site samplers which exceed the PSG value are specifically analyzed for plutonium. In the last ten years only two exposed filters have been subject to the requirement for plutonium analyses. Both of these incidents occurred in January 1987 prior to the recent field activities at the 903 Pad Mound and East Trenches Areas. Plutonium analyses of these filters indicated near fallout levels of plutonium.

Results of the Plant RAAMP samples are published in the Monthly Environmental Monitoring Report and summarized on a yearly basis in the Annual Environmental Monitoring Report. Appendix I provides summary data for at least ten years for the RAAMP program. These data are arranged by sampler location as determined by on site perimeter or community samplers. As the tables indicate since 1977 mean annual plutonium levels at all on site samplers have been less than 3% of the DOE DCG of 0.02 pCi/m^3 of TLL alpha. Perimeter and community ambient air samplers have recorded mean annual plutonium concentrations below 0.4% of the DOE DCG value since their installation.

7.1.2 Routine Nonradioactive Ambient Air Monitoring

The routine nonradioactive ambient air monitoring program was instituted at the Rocky Flats Plant to address regulations concerning criteria air pollutants (NAAQS). This program consists of one sampling station and includes some limited PM 10 sampler data. The NAAQS sampling program was not instituted to yield data specific to any area undergoing remedial investigations; however, the following information is presented for completeness.

Ambient air monitoring at the Plant includes the monitoring of the following pollutants total suspended particulates (TSP) ozone sulfur dioxide carbon monoxide nitrogen dioxide and lead These six parameters are criteria pollutants regulated by the EPA and the State of Colorado through the Clean Air Act (CAA) and they are monitored at a single location near the east entrance to the Plant throughout the year This sampling is conducted in an open area near a traffic zone generally downwind from Plant buildings This sampling location is not intended to provide pollutant concentration data for site specific remedial investigation activities such as that conducted in the 903 Pad Mound and East Trenches Areas during the summer of 1987 As discussed in Section 7.2 short term site specific sampling was conducted to monitor such activities

In general the values for all of the analyzed criteria pollutants (TSP lead sulfur dioxide carbon monoxide nitrogen dioxide and ozone) were measured at 30 percent or less of any applicable limits or guidelines with the exception of TSP and ozone The highest TSP value for 1986 (a 24 hour sample) was 156 micrograms per cubic meter (ug/m^3) which is 60 percent of the primary 24 hour National Ambient Air Quality Standard (NAAQS) standard of $260 \text{ ug}/\text{m}^3$ The annual TSP geometric mean value for 1986 was $48 \text{ ug}/\text{m}^3$ which is 64 percent of the NAAQS primary annual geometric mean standard of $75 \text{ ug}/\text{m}^3$

The maximum 1 hour 1986 ozone value was 0.18 parts per million (ppm) which is 151 percent of the NAAQS primary one hour standard of 0.12 ppm The second highest 1 hour ozone value was 0.17 ppm These ozone values are consistent with levels measured in the general Denver metropolitan area during high pollution episodes Volatile organics emissions resulting from RI activities would not be sufficient to impact ambient ozone levels as measured at this location

713 Special Dust Resuspension Studies

The 903 Pad Mound and East Trenches Areas has been the source of considerable activity in past years. Subsequent to the removal of the drums in 1968 efforts were made to stabilize the soil in the storage area with fill material and soil sterilant followed by the completion of an asphalt cover in November 1969. In the summer of 1976 contaminated soil was hand excavated from one small area at a time placed in plastic bags and subsequently boxed for off site disposal. A total of 125 000 pounds of contaminated soil was removed by the end of the summer and the area was then covered with clean topsoil and reseeded. In June 1978 mechanized equipment was used to excavate the majority of the contaminated soil in the 903 lip site (Barker 1982).

A Field Instrument for Detecting Low Energy Radiation (FIDLER) was used on two occasions to investigate areas on and adjacent to the 903 drum storage site. This occurred in 1973 (Krey 1973) and again in 1980 following the 1978 soil removal activities (Environmental Sciences Branch 1981a and Barker 1982). In 1982 a complete gamma survey using a Phoswich Detector was conducted of the 903 Pad and East Trenches Areas (Application Technology Branch 1984). Finally in 1984 the Phoswich Detector was used to survey the berm between the 903 Pad and the East Trenches Areas. As a result of this investigation it was found that the berm area had been contributing relatively significant amounts of resuspended plutonium to the environment (Hodgin 1983).

A number of studies have been conducted at Rocky Flats to investigate background levels of plutonium. No true background for plutonium exists since

plutonium is a man made element Nevertheless plutonium is found worldwide in extremely low concentrations due to atmospheric testing of nuclear weapons and the consequent fallout of plutonium from the atmosphere Background levels of plutonium near the Plant were estimated in a Colorado State University study at less than 0.045 picocuries per gram (less than 0.1 dpm/gm) in 1979 (Whicker 1979)

Research conducted at the Plant indicates that the classical theory of soil resuspension by saltating soil particles does not apply at Rocky Flats (Sehmel 1980 Environmental Studies Group 1981a Environmental Sciences Branch 1981b Environmental Sciences Branch 1982 Environmental Sciences Branch 1983 Environmental Sciences Group 1984 Application Technology Branch 1984 Application Technology 1986) The classical wind erosion theory for soil predicts resuspension to increase based on a third power relationship with wind speed On this basis the airborne plutonium concentration should reflect the soil concentration as the dust in the air would originate uniformly from the soil In a special study at the 903 Pad Area airborne concentrations did not correlate with average wind speed and wind direction data nor were any correlations observed between samplers (Environmental Sciences Branch 1981a and 1983) In fact during numerous years of study only two instances were identified in which resuspension was clearly affected by wind These instances were major wind storms of 100 and 130 mph winds The anticipated correlation between other high wind events common in the area and elevated plutonium concentrations is not borne out by the data

While no working model for dust resuspension has been developed for the Plant the research conducted at Rocky Flats indicates that 70 percent of all airborne plutonium activity was on particles greater than 15 microns in median aerodynamic diameter Such large dust particles are in the non respirable size range Soil samples

at the eastern buffer zone boundary are at or below background levels confirming the role of large particles in instances of elevated on site airborne plutonium concentrations Finally the RAAMP samplers operational at the RFP for over ten years document that TLL alpha and plutonium concentrations have been far less than the applicable DCG

7.2 REMEDIAL INVESTIGATION AIR SAMPLING RESULTS

7.2.1 Radiometric Survey

A radiometric survey of the entire Plant security area was completed in 1984 using a Field Instrument for Detecting Low Energy Radiation (FIDLER) Operations of the FIDLER probe gamma survey instrument are reviewed in Case and others (1971) This survey also included limited areas outside the Plant security area The 903 Pad Mound and East Trenches Areas within the security fence were surveyed as a part of this study

The survey results indicated background levels of ionizing radiation FIDLER surveys were also performed at each specific drilling location prior to beginning drilling activities and after completion of the drilling activities The results of these surveys indicated background levels of ionizing radiation with the exception of the cuttings at 15 87 which were twice background

Core samples were smeared and the smears counted using an air proportional detector Smears of all cores indicated background levels Personnel were required to wear DOE white cotton coveralls and boot covers when walking inside the fenced area of the 903 Pad Area Whenever drilling was being conducted personnel were required to wear Saranex coveralls gloves shoe covers and supplied air respirators

Equipment and personnel were always monitored for radioactive contamination when exiting the area. Personnel were monitored using an air proportional alpha survey meter. No contamination was noted on personnel during the field activities.

Equipment was monitored with an air proportional alpha survey meter or by taking smears of the surface and counting the smear for alpha activity. No equipment was ever found to be contaminated with radioactive material.

The extensive monitoring that was conducted and the fact that no contamination was ever found on equipment or personnel indicates that resuspension of radioactive material was not a problem at the 903 Pad Area.

High volume samplers were installed and operated for the duration of the borehole and well drilling activity at the 903 Pad Mound and Trench Areas. The samplers were located downwind of each drilling site. At the conclusion of the daily activity, the filters from the air samplers were removed and analyzed for TLL alpha activity.

The RAAMP data for plant sites S 5 S 6 S 7 S 8 S 9 and perimeter sites 38 39 and 40 are presented in Table 7 1 for the months of July August and September. The perimeter sampling sites in Table 7 1 were selected because they are downwind of on site samplers 7 8 and 9. This data covers the period of borehole and well drilling activity at 903 Pad Mound and East Trenches Areas. Based on wind rose data for the Plant, these air sampler data have a high probability to indicate releases resulting from drilling and vehicular activity during this period of time.

RAAMP AIR SAMPLING SITES

PLUTONIUM 239 AND 240 CONCENTRATIONS (pCi/m³)

	S 5	S 6	S 7	S 8	S 9	S 38	S 39	S 40
				JULY DATA				
LCL	000064	00018	003735	002666	001644	000005	000001	000002
POINT ESTIMATE	000047	000016	000497	000892	001317	000001	0002	000002
UCL	000029	000005	000190	000696	000362	000015	000001	000007
				AUGUST DATA				
LCL	000076	000134	004170	003018	001859	000008	000003	000000
POINT ESTIMATE	000059	000022	000561	000995	001477	000003	000000	000001
UCL	000038	000010	000218	000776	000405	000018	000003	000010
				SEPTEMBER DATA				
LCL	000088	000150	004605	003370	002074	000010	000005	000002
POINT ESTIMATE	000071	000028	000625	001098	001637	000005	000002	000004
UCL	000047	000015	000246	000856	000448	000021	000005	000013

The monthly averages for plutonium at the perimeter sampling sites (S 38 S 39 S 40) during the site investigation activity are not significantly higher than the historical averages for the same sampling sites. The on site samplers (S 5 S 6 S 7 S 8 and S 9) have recorded values during site investigation activities below the DCG. The RAAMP samplers show no difference in plutonium concentrations as a result of the drilling activity during the months of July August and September.

7.2.2 Volatile Organic Compound Survey

Personnel trained in industrial hygiene surveyed the 903 Pad Area on March 25 1987 the Mound Area on April 23 1987 and the East Trenches Area on April 8 1987 for the presence of volatile organics in ambient air. The surveys were done with dreager tubes sensitive to PCE and TCE in the parts per million range. These two compounds were chosen since investigations prior to March 1987 had indicated PCE and TCE were the most commonly found contaminants at the 903 Pad Mound and East Trenches Areas and they were also found in higher concentrations than other contaminants.

Air sampling was conducted six inches above the ground at numerous point locations throughout the 903 Pad Mound and East Trenches Areas. All values were below detection limits. Additionally soil gas sampling results (Appendix C) of the 903 Pad Mound and East Trenches Areas indicate only limited areas of detectable volatile organics present in the soil gas. A more complete discussion of 1987 soil gas results is given in Sections 4.0 and 5.0. All of the above results demonstrate that only a minimal amount of volatile organics are contributed to ambient air by the 903 Pad Mound and East Trenches Areas.

80 BIOTA

81 FLORA

The Rocky Flats Plant is located approximately 6 000 feet above sea level where plains grassland vegetation meets lower montane forest

The 1980 Environmental Impact Statement for the Plant (DOE 1980) describes floral species that are representative of the tall grass prairie short grass prairie lower montane and foothill ravine regions Some areas are dominated by introduced Eurasian weeds Weber and others (1974) inventoried the flora at the Rocky Flats site from June through September of 1973 and reported 327 species of vascular plants 25 lichens 15 bryophytes and one macroscopic green algae species An annotated list of species occurring on the site is given in Appendix H Investigations conducted for the Rocky Flats Plant Environmental Impact Statement resulted in a finding that no threatened or endangered species occurred at the Plant

Domestic livestock grazing has not been allowed in the area of investigation since 1951 and some disturbed areas have been reseeded with native and introduced grass mixtures (DOE 1980) The vegetation is recovering from prior grazing as evidenced by the common presence of grasses like big bluestem and side oats grama which are sensitive to disturbances

Vegetation within the 903 Pad Area has been impacted by construction activities and the release of plutonium contaminated cutting oil and carbon tetrachloride from machining operations Vegetation from the Rocky Flats Plant has been periodically sampled and analyzed for plutonium 239 and 240 plutonium 238

and americium 241 Since 1975 this sampling has been carried out by clipping vegetation within 10m² frames located randomly at ten sites in each of two plots (Rockwell International 1983) Plot A was located southeast and relatively near the 903 Pad Area Plot B was located northeast of the 903 Pad Area approximately twice as far from the 903 Pad as Plot A (Figure 8 1) A third control plot was located in various areas expected to be unaffected by Plant operations The vegetation samples were dried ashed and analyzed for radionuclides (Rockwell International 1983) Prior to 1975 vegetation was sampled ashed and analyzed for radionuclides but the vegetation sampling procedure was significantly different The results of vegetation sampling and radionuclide analyses have remained comparable throughout all sampling events since 1975 Vegetation samples were last collected in 1983

Significant variability has been seen in all the data In general levels of plutonium 239 and 240 in vegetation collected at Plot A have been elevated compared to vegetation collected at Plot B or in the control area The plutonium 239 and 240 concentrations at Plot A have varied from 0.068 to 0.415 picocuries per gram of ash whereas the concentrations of these radionuclides in Plot B have varied from 0.004 to 0.066 picocuries per gram of ash The concentrations of these radionuclides in Plot B have been indistinguishable from the control plot (Rockwell International 1982 and Rockwell International 1983) Concentrations of plutonium 238 and concentrations of americium 241 have shown no identifiable differences between plots The data for individual plots have shown no discernible trends with time

Radioecology studies which began in 1972 have been conducted at the Rocky Flats Plant by Colorado State University These studies centered on plutonium released from the 903 Pad and its behavior in the environment

In studies reported by Little and others (1980) soil litter vegetation common arthropods and small mammals were collected and analyzed for plutonium. Vegetation was clipped about 15 cm above the soil oven dried and analyzed by liquid scintillation or alpha spectrometry. Results of these studies indicated that the top 21 cm of soil contained >99% of the total plutonium inventory of the ecosystem. The fractions of total Pu in the non soil compartments were orders of magnitude lower than in the soil compartment. Litter contained a higher fraction of the total Pu inventory than vegetation which in turn contained a larger fraction than the animal compartments studied. Comparison of study results in which washed and unwashed vegetation samples were analyzed for plutonium indicated that much of the plutonium associated with vegetation was due to dust and not to plutonium uptake into the vegetation (Arthur 1977 and Mecker 1978). These radioecology studies corroborated the results of other investigations that plutonium moves in the environment principally by physical rather than by physiological mechanisms (Whicker 1979).

In summary the vegetation around the 903 Pad Area does not appear to be physiologically stressed from the concentrations of plutonium in the soil. Studies show that contamination through physiological uptake of plutonium by vegetation is substantially less than surficial dust plutonium contamination. Therefore it appears that vegetation has not been affected by plutonium contamination in the 903 Pad Area.

8.2 WILDLIFE

A list of mammals birds amphibians and reptiles observed at the Plant is given in Appendix H.

There are no effective barriers to animal migration or movement on or off the undeveloped areas of the Plant. This area supports a variety of animals classically associated with the western prairie regions. No rare or endangered species were reported or found among the wildlife inhabiting or migrating through the area when surveyed for the Environmental Impact Statement (Appendix H). The most common large mammal at Rocky Flats site is the mule deer. Most of the estimated 100 to 125 deer appear to be permanent residents of the site. White tailed jack rabbits and the desert cottontail also inhabit the area. Carnivores in the area include coyote, red fox, striped skunk, and long tailed weasel. Badger and raccoon are occasionally observed. Muskrat occur in the vicinity of the streams and ponds (DOE 1980).

Winsor (1975) initiated a mark and recapture program during the summer of 1973 to estimate dynamics and biomass of the small mammal population. Species captured included deer mouse, thirteen line ground squirrel, northern pocket gopher, hispid pocket mouse, silky pocket mouse, harvest mouse, meadow vole, and house mouse (DOE 1980).

Commonly observed birds include western meadowlarks, horned larks, mourning doves, and vesper sparrow. A variety of ducks, killdeer, and red winged blackbirds are seen in areas adjacent to ponds. Mallards and other ducks frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh hawks, red tailed hawks, Ferruginous and American rough legged hawks, and great horned owls (DOE 1980).

Bull snakes and rattlesnakes are the most frequently observed reptiles. Eastern yellow bellied racers have also been seen. The eastern short horned lizard has been reported on the site, but these and other lizards are not commonly observed. The

western painted turtle and the western plains garter snake are found in and around many of the ponds (DOE 1980)

Radioecology studies have been conducted on wildlife in the area of the 903 Pad. These studies included dissecting small mammals and analyzing individual tissues of bone, GI tract, hide, kidney, lung, liver, and muscle. The samples were oven dried prior to plutonium analysis and were analyzed by liquid scintillation or alpha spectrometry (Little and others 1980). Arthropods were also analyzed for plutonium. Analysis found in Table 8.1 revealed that arthropods and small mammals had plutonium concentrations 100 times lower than soil with no significant differences found between concentrations of the seven tissue types studied (Little and others 1980). Whicker (1979) found that plutonium levels in small mammals were occasionally non detectable. He also discovered that as with vegetation, plutonium levels in arthropods were significantly correlated to plutonium levels in soil and that most plutonium activity was associated with dust rather than biological uptake. This again corroborates other investigation results that plutonium moves in the environment principally by physical rather than physiological mechanisms.

Concentrations of Pu 239 in arthropods (Table 8.2) were too variable to show statistically significant differences between species or taxonomic groups. Also, it was shown that there was no significant difference between collection data or types of small mammal tissue.

The potential for plutonium uptake into animals was investigated to determine if there was a detrimental impact on the animals. Detailed studies were conducted on a number of small mammals and a limited study was conducted on arthropods. The detailed studies included species occurrence, population density, biomass,

TABLE 8 1
(LITTLE AND OTHERS 1980)

DISTRIBUTION OF PLUTONIUM IN SAMPLES FROM THE ROCKY FLATS STUDY MACROPLOT

COMPARTMENT	MEAN	N	95% CONFIDENCE INTERVAL
<u>Plutonium concentration, dpm/g</u>			
Soil 0 3 cm	1 850	72	1 230 2 480
Soil 3 21 cm	233	309	154 312
Litter	914	29	698 1 130
Vegetation	63 4	76	34 8 92 0
Arthropods *	12 6	23	7 19 18 0
Small mammals	14 4	304	5 29 23 5
<u>Fraction of Total Pu</u>			
Soil 0 3 cm	5 0 x 10 ⁻¹		2 5 x 10 ⁻¹ 7 4 x 10 ⁻¹
Soil 3 21 cm	5 0 x 10 ⁻¹		2 5 x 10 ⁻¹ 7 5 x 10 ⁻¹
Litter	2 9 x 10 ⁻³		1 6 x 10 ⁻³ 4 2 x 10 ⁻³
Vegetation	1 0 x 10 ⁻⁴		4 1 x 10 ⁻⁵ 1 6 x 10 ⁻⁴
Arthropods *	1 2 x 10 ⁻⁵		4 6 x 10 ⁻⁶ 2 0 x 10 ⁻⁶
Small mammals	3 3 x 10 ⁻⁹		6 6 x 10 ⁻¹⁰ 6 0 x 10 ⁻⁹
<u>Concentration ratio *</u>			
Soil 0 3 cm	1 0 x 10 ⁰		
Soil 3 21 cm	1 3 x 10 ⁻¹		6 6 x 10 ⁻² 1 9 x 10 ⁻¹
Litter	4 9 x 10 ⁻¹		2 9 x 10 ⁻¹ 7 0 x 10 ⁻¹
Vegetation	3 4 x 10 ⁻²		1 5 x 10 ⁻² 5 4 x 10 ⁻²
Arthropods	6 8 x 10 ⁻²		3 1 x 10 ⁻³ 1 1 x 10 ⁻²
Small mammals	7 8 x 10 ⁻³		2 2 x 10 ⁻³ 1 3 x 10 ⁻³

* Compartmental Pu inventory (dpm/m²) mean biomass (g dry/m²) x mean concentration (dpm/g dry)
 Fraction of total mean compartmental inventory (dpm/m²) + total inventory (dpm/m²)
 Concentration ratio mean concentration of compartment (dpm/g) + mean concentration of 0 3 cm soil (dpm/g)

* N - number of samples for which the mean is calculated for arthropods and vegetation
 N is the number of groups of individuals analyzed for small mammals the number of tissue samples not individual animals

* Includes data collected by BLY (1977) unpublished manuscript Dept Radiology and Radiation biology Colorado State University Fort Collins
 Relative to 0 3 cm soil

**Pu 238 AND Pu 239 CONCENTRATIONS (dis/min g⁻¹)
IN ROCKY FLATS ARTHROPODS
BASED UPON 1973 1973 1976 COLLECTIONS ***

	SEASON	ORDER	COMMON NAMES	Macroplot									
				1		2		H		P			
				Pu 238	Pu 239	Pu 238	Pu 239	Pu 238	Pu 239	Pu 238	Pu 239		
Spring	Coleoptera	beetles		0 31	20 4	*	1 55						
	Homoptera	leafhoppers		0 25	13 6		1 04						
	Orthoptera	grasshoppers		0 06	4 16		0 54						
Summer	Coleoptera	beetles		0 06	7 54		0 64	5 42	294				
	Homoptera	leafhoppers		0 15	9 02		0 44	9 37	522				
	Orthoptera	grasshoppers		0 07	4 45	0 01	0 26	5 13	272				
Fall	Coleoptera	beetles		0 33	20 3	0 02	0 23				0 37		
	Homoptera	leafhoppers		0 09	1 3	0 03	0 55			0 01	0 32		
	Orthoptera	grasshoppers		0 59	28 0		0 52			0 01	0 14		
	Isopoda	sowbugs		1 13	61 0		0 55						
All Season	Araneae	spiders		0 31	18 9		0 81	4 23	256		1 76		
	Hemiptera	bugs		0 09	5 78	0 02	1 05	1 14	67		0 23		
	Hymenoptera	bees & ants		0 27	15 3	0 08	0 95	3 25	179		0 16		
	Mean (dis/min g ¹)			0 29	16 1	0 03	0 70	4 76	265	0 01	0 50		
S				0 08	4 3	0 01	0 10	1 12	61	0 00	0 26		
X													

Twenty two of 38 Pu 239 counting errors (s/count) were less than 5% Errors ranging from 6.30% were associated with the remaining samples all of which were 2 dis/min g⁻¹ Twenty of 26 Pu 239 counting errors ranged from 5% to 144%

Subclass not an order

indicates data reported as zero or negative
The standard error of the mean (s/square root of n)

reproduction and physical size of the whole carcass as well as organs. Additionally, pathological examinations of small mammals were carried out by x-ray analysis of the skeleton, microscopy for lung tumors, and necropsy for general pathology and parasite occurrence. Arthropods were studied through community structure and biomass (Whicker 1979).

Minor differences in biological attributes of animals and arthropods of contaminated and non-contaminated areas did occur, but none could be related to plutonium level. The levels of plutonium found in the tissues of animals living in contaminated areas (Table 8.1) were insufficient to produce radiation doses causing obvious biological changes, and no evidence of cancers or other radiogenic diseases were found. It is possible that subcellular biological effects such as chromosome aberrations may occur in areas highly contaminated with plutonium; however, population level changes would likely not occur due to interbreeding with the surrounding pool of normal genetic information. These studies indicate that plutonium at the levels present at the site is not expected to pose an ecological hazard (Whicker 1979).

Bly and Whicker (1979) studied arthropods in order to determine the chances for plutonium dispersal. Arthropods were studied due to their mobility and rapid population turnover rates, which would cause arthropods to disperse more plutonium than other animals. The insects that were collected for plutonium analysis included leafhoppers, aphids, beetles, grasshoppers, and crickets. The conclusion again revealed that plutonium in soil and insects were closely correlated. Less plutonium activity was found in insects than in the soil from which they came, yet there was considerably more variation in arthropod plutonium concentrations than in soil plutonium concentrations. The plutonium levels associated with arthropods could

have been due to either physiological uptake or dust contamination of the insects. The fractions of plutonium contamination associated with either compartment was not separated out. It has been determined that arthropod biomasses were substantially higher than those of small mammals in the grassland system yet the total plutonium concentration in the arthropod community was found to be only 10^{-8} of the total plutonium inventory of the ecosystem.

Due to the mobility of mule deer at the Plant they have also been studied in relation to plutonium dispersal. Mule deer ingest and transport plutonium associated with vegetation and soil. The majority of the plutonium is redeposited on Plant property in fecal pellets. It has been calculated that transport offsite by deer amounted to less than 10^{-7} of the plutonium inventory annually due to the low levels of plutonium found on the ingested vegetation as well as the low uptake rate of plutonium into the deer (Whicker 1979).

These studies have revealed that total biological transport of plutonium off site is on the order of 0.001% per decade. With plutonium slowly weathering into deeper soil layers it is expected that biological transport will diminish with time (Whicker 1979).

8.3 AQUATIC LIFE

Both South Walnut Creek and Woman Creek which are both potential receptors of runoff from the 903 Pad Area support a diverse community of benthic organisms composed of mayflies, caddisflies and other forms typical of clean water streams. Due to the past history of South Walnut Creek and its receipt of nutrients it supports a larger algal population than Woman Creek. In Woman Creek, redbelly dace minnows

are abundant in the stream and in the ponds and a few bluegill are also present South Walnut Creek does not appear to support a fish population

As a portion of the radioecology research conducted at the Plant CSU analyzed aquatic samples from on site ponds during 1971 to 1974 The research revealed that plutonium which had been discharged in the past was rapidly redeposited into the bottom sediments (DOE 1980)

Comparisons were made between levels of plutonium in aquatic life and levels of plutonium in filtered pond water These comparisons were based on concentration ratios (CRs) which are defined as

$$CR = \frac{\text{picocuries per gram seston (dry weight)}}{\text{picocuries per ml water (filtered)}}$$

Results of the CRs revealed that seston (phytoplankton some detrites small zooplankton) had a high concentration of plutonium relative to water in the order of 10^4 to 10^5 Zooplankton analysis revealed CRs relative to filtered water in the 10^4 range According to Paine (1980)

If ingestion is the primary route of transfer in these organisms then higher concentration factors would be expected from the simple phytoplankton to zooplankton food chain Since an increase in trophic level concentration of plutonium did not occur there appears to be selective mechanisms that discriminate against plutonium at this level This would result in a decreased potential hazard when considering the transfer of plutonium through ingestion routes

Crayfish a large invertebrate common to the pond system showed CRs relative to unfiltered water in the range of 320 to 1290 with a mean value of 830 These values are similar to those found in other studies Seventy seven percent of the plutonium in crayfish is associated with the exoskeleton even though the crayfish were scrubbed extensively The benthic origin of these organisms

probably explains the high plutonium concentrations associated with the exoskeleton

Fish flesh and bone from Ponds A and C on the Plant and off Plant reservoirs were never above the Minimum Detectable Activity (MDA) of 0.30 d/min per sample even when several samples were composited. Whole fish however contained measurable amounts of plutonium in the gut contents, the head and outer skin. This suggests that plutonium is being discriminated against at this trophic level.

Mean concentration routes for rooted vegetation found in the ponds varied from 5.1 for standing vegetation to 11.2 for roots.

These studies on the aquatic environment indicate no evidence of ecological hazard for the plutonium present in the sediments. Representative levels of plutonium in the sediments are 0.8 pCi/g in Woman Creek and 1.9 pCi/g in South Walnut Creek. The majority of the plutonium is tied up in the sediment and this sediment is relatively immobile. Also, indications are that relatively little bioaccumulation of plutonium occurs.

8.4 CONCLUSIONS

Results of studies conducted on the biota at the Rocky Flats Plant indicate that the majority of the plutonium contamination is tied up in soils and sediments and is therefore relatively immobile. Physiological uptake of plutonium by vegetation is substantially less than surficial plutonium contamination.

Radioecology studies conducted on wildlife relating to plutonium uptake have not shown any obvious biological changes and no evidence of cancers or other radiogenic diseases. Other studies on wildlife (arthropods and mule deer) related to

the dispersal of plutonium have revealed that total biological transport of plutonium is insignificant

Studies conducted on aquatic organisms have revealed that relatively little bioaccumulation of plutonium occurs between the trophic levels

In summary the radioecology studies on biota have corroborated other investigations that plutonium moves in the environment principally by physical rather than by physiological mechanisms

9 0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

This section identifies potential receptors public health impacts and the environmental impacts of contaminants found at the 903 Pad Mound and East Trenches Areas Previous sections of this report have described remedial investigation sampling results Samples were collected from air soils sediment surface water ground water flora and fauna Soil gas techniques and geophysical techniques were also used to investigate the 903 Pad Mound and East Trenches Areas These data were used to evaluate contaminant presence distribution migration and fate

As discussed in Sections 4 0 5 0 and 6 0 contaminated soil ground water and surface water occur at the 903 Pad Mound and East Trenches Areas The contaminants of greatest concern from a public health perspective are volatile organic compounds (VOCs) plutonium and americium VOCs occurred in both soil and water while plutonium and americium contamination appears to be confined to the soils Uranium or tritium contamination is not apparent in any media Metals were not found to be a contaminant of the soils however strontium and occasionally zinc were elevated above estimated background levels in surface water and alluvial ground water Selenium also appears to be elevated above background levels in alluvial ground water at one location near the 903 Pad Area

9 1 POTENTIAL RECEPTORS

Based on 1980 Census data approximately 1 585 individuals live within four miles of the Rocky Flats Plant Approximately 2 million people live within a 50 mile

radius of the Plant. Population density is greatest to the south and east of the Plant (Figure 3.1). A buffer zone around the manufacturing facilities is maintained as a restricted access area by the Plant and is actively patrolled by armed security guards. Therefore, a residence closer than 1.6 miles from the 903 Pad Mound and East Trenches Areas is not possible. Currently the closest residence is 2.1 miles from the center of these areas. The only possible routes of exposure to 903 Pad Mound and East Trenches contamination are through direct exposure to waste sources and contaminated soil, inhalation of contaminated air, ingestion of contaminated ground water, and ingestion of contaminated surface water. Without primary exposure to contaminants through one of the above media, no secondary exposure to contamination can occur. Secondary exposure to contamination is defined as exposure to contamination caused by a change in the mode of transport of that contaminant. For instance, primary migration of volatile organics may occur in the surface water of a creek. Secondary exposure could occur through consumption of food crops that have taken up the volatile organic compounds from irrigation water whose source was that contaminated creek.

9.1.1 Direct Source Contact Potential Receptors

Since the entire area of discussion (903 Pad Mound and East Trenches) is within the Plant security area or buffer zone and access to both the Plant and the buffer zone is restricted, direct exposure of the public to contaminated soil is not possible. Any potential for contact with contaminated soil will be limited to workers involved in investigative and remedial activities. All remedial action workers will be protected by protective clothing, the use of respirators when necessary, and by air monitoring during field activities. Industrial hygienists and health physicists will

prepare a personnel protection plan prior to the initiation of remedial activities. Results of bioassay and whole body counting programs conducted for past remedial activities at the most radioactively contaminated area (903 drum storage and lip sites) indicated that no measurable exposures were incurred by personnel involved in the cleanup efforts (Barker and others 1982).

9.1.2 Potential Receptors of Contaminated Air

Long term exposure of individuals to directly resuspended dust and to contaminated air can only occur to those individuals that are residents near the Plant because greater distances from the Plant will cause dilution of any plume by advection, dispersion, and diffusion. To be exposed to contaminated air, individuals would also need to be within a plume of contamination leaving the Plant. Winds at the Plant are predominantly from the northwest. A wind rose for the Plant is provided in Figure 7.1. The low population density within four miles of the Plant indicates that relatively few individuals are potential receptors of contaminated air.

9.1.3 Potential Receptors of Contaminated Ground Water

Table 9.1 presents all water supply well locations within two miles of the 903 Pad Mound and East Trenches Areas. The closest downgradient water supply wells (wells 11, 12, 13, 16, 17, 20) are outside the two mile radius but have been included in Table 9.1. Their locations were obtained from records in the Colorado State Engineer's Office. Wells 11 and 12 approximately 2.2 miles east and north of the 903 Pad Mound and East Trenches Areas could not be physically located in the summer of 1986. These two wells would be located on City of Broomfield land and City employees had no knowledge of these wells (Rockwell International 1986c). The

TABLE 9 1
WELLS WITHIN TWO MILES OF
THE 903 PAD MOUND AND EAST TRENCHES AREAS
PLUS THE NEAREST DOWNGRADIENT WELLS

PERMIT NUMBER	QUARTER	LOCATION SEC.	TSP.	RNG.	USE	WELL DEPTH (feet)	WATER LEVEL (feet)	YIELD (gpm)	OWNER	DATE WELL CONSTRUCTED
119287	SW/NW	31	T 1S	R 69W	1	Unk	Unk	Unk	Roberts B A	4/22/81
105613A	NE/NW	31	T 1S	R 69W	1	Unk	Unk	Unk	Hart G D	6/22/79
108871	NW/NW	31	T 1S	R 69W	1	Unk	Unk	Unk	Smith M R	7/23/79
105681	NE/NE	32	T 1S	R 69W	0	Unk	Unk	Unk	Fuentes J J	4/18/79
106022A	NW/NW	32	T 1S	R 69W	1	Unk	Unk	Unk	Kingsburg D	5/4/79
121149	NW/NW	32	T 1S	R 69W	1	Unk	Unk	Unk	Koia R W	7/28/81
104756	NE/NE	19	T 2S	R 69W	0	Unk	Unk	Unk	Welt D L	4/8/81
26942F	NE/NW	19	T 2S	R 69W	8	Unk	Unk	Unk	Cook M E	11/8/84
139972	SE/SE	19	T 2S	R 69W	3	Unk	Unk	Unk	Coleman J R	6/17/85
131841	NE/NW	19	T 2S	R 69W	6	Unk	Unk	Unk	Cook M E	8/2/83
26937F	NW/NW	19	T 2S	R 69W	8	Unk	Unk	Unk	Cook M E	11/3/84
26	NE/NE	19	T 2S	R 69W	1	66	27	15	Ledwig A E	6/27/57
223	SW/SE	19	T 2S	R 69W	1	110	10	6	Schofield James & Betty	8/28/57

majority of the wells presented in Table 9 1 are used to obtain drinking water for either humans or livestock The nearest registered downgradient wells (wells 20 13 16 and 17) are located approximately 2 6 miles east and slightly south of the 903 Pad Mound and East Trenches Areas

9 1 4 Potential Receptors of Contaminated Surface Water

The intermittent Woman Creek (isolated from surface water runoff from the Plant by the South Interceptor Ditch located due north of the creek) flows to the south of the 903 Pad Mound and East Trenches Areas and enters Standley Lake approximately four miles east of the Plant boundary Standley Lake supplies drinking water to approximately 150 000 inhabitants of the cities of Westminster Northglenn and Thornton Standley Lake is also used for irrigation water boating and fishing South Walnut Creek originating to the west of the 903 Pad Mound and East Trenches Areas flows northeast and joins North Walnut Creek and an unnamed tributary within the Plant buffer zone before flowing into Great Western Reservoir located approximately one mile east of this confluence

9 2 PUBLIC HEALTH IMPACTS

9 2 1 Direct Source Contact Exposure

Soil at the surface of the 903 Pad Mound and East Trenches Areas is contaminated with plutonium and americium Maximum plutonium and americium concentrations in composite soil samples from drilling cores that include the ground surface were 180(10) pCi/g and 22(6) pCi/g These concentrations occurred in soils at the 903 Pad Area Concentrations of these radionuclides were generally two orders of

magnitude less at the Mound and East Trenches Areas but nevertheless elevated above the estimated background levels of 0.10(0.20) pCi/g and 0.28(0.16) pCi/g for plutonium and americium respectively. The maximum plutonium concentrations for each area exceed the Colorado State standard of 0.01 uCi/m² (1 pCi/g) which was established for building construction purposes (construction is not prohibited but special construction techniques are required). At the 903 Pad Area maximum plutonium concentrations also exceed EPA guidance which provides a screening level for soil of 0.2 uCi/m² (20 pCi/g) for uncontrolled access (EPA 1977). The screening level indicates a need for further testing to determine whether dose limits are exceeded in areas having uncontrolled access. VOC contamination of the soils is generally at depth and related to contaminated ground water. However as discussed in Section 9.1.1 there is no potential for direct exposure of the public (access is controlled) or any livestock to the 903 Pad Mound and East Trenches Areas soil contamination. Therefore there is no public health impact for this route of exposure.

9.2.2 Exposure to Contaminated Air

An extensive air monitoring network known as the Radioactive Ambient Air Monitoring Program (RAAMP) is maintained at the Plant. This network has found ambient air samples to be well within applicable regulations and guidelines for the protection of human health and the environment for all radioactive contaminants that could possibly have originated from the 903 Pad Area. No anomalous values were noted that correlated with any of the 903 Pad Area field activities.

As discussed in Section 4.0 plutonium (and americium) are elevated above background in surface soil at the 903 Pad Area and to a lesser extent at the Mound and East Trenches Areas. However as discussed in Section 7.0 movement of

resuspended dust at the Plant results in lower than predicted concentrations of dust resuspended in the air. The majority of this resuspended dust settles out within one kilometer of the Plant. Also, the RAAMP system has detected only very low levels of ambient radioactivity on captured resuspended dust particles. The air sampling results demonstrate that currently there is no public exposure off site to radionuclides via inhalation.

Ambient air sampling for volatile organic compounds was performed six inches above the land surface at numerous point locations throughout the 903 Pad Area. Results of this survey indicate that all values were below detection limits.

Ambient air sampling in the breathing zone for volatile organics during drilling activities at these areas failed to detect the presence of volatile organics. Based on the lack of detectable contamination of air due to any of the activities in these areas, there is no public health impact from the air pathway.

9.2.3 Exposure to Contaminated Ground Water

An extensive ground water monitoring system (approximately 150 wells) has been installed at the Plant. Forty-five ground water monitoring wells have been drilled within and downgradient of the 903 Pad Mound and East Trenches Areas.

The highest concentrations of volatile organics in alluvial ground water were found at wells 1-71, 2-71, 1-74, 42-86, 3-74, and 15-87. The highest concentrations of 1,1-DCE (673 ug/l), 1,2-DCA (400 ug/l), 1,2-DCE (364 ug/l), and TCE (26,000 ug/l) were reported in well 2-71 located within the 903 Pad Area. Also within the 903 Pad Area, the highest concentrations of CHCl_3 (1,525 ug/l at well 1-71) and 1,1,1-TCA (2,892 ug/l at well 1-71) were reported for alluvial ground water. High

concentrations of volatile organics were found in the Mound Area in well 1 74. Concentrations of PCE were reported as high as 528 000 ug/l. This is the highest PCE concentration ever reported for alluvial ground water at the Plant site. However concentrations of PCE at this well have been as low as nondetectable (most recent sample) and typically have been in the range of 10 000 to 100 000 ug/l. Another potential source of VOCs is at the East Trenches Area in the vicinity of wells 3 74 and 42 86. The highest concentration of CCl_4 was observed at this location (4 835 ug/l at well 42 86) however concentrations of VOCs are generally lower than those observed in alluvial ground water at the 903 Pad and Mound Areas. It should be noted that these reported maximum concentrations of VOCs are considered qualitative data because the laboratory performing the analyses did not meet all QA/QC requirements (see Appendix G and Section 5.0 for further discussion). Samples collected subsequently and split with another laboratory indicate concentrations are considerably lower than reported here.

Alluvial ground water flow is generally toward the east across the 903 Pad and Mound Areas toward the East Trenches Area. However there are flow components from the 903 Pad Area and southern portion of the East Trenches Area to the south toward the South Interceptor Ditch and Woman Creek. Also there are flow components at the Mound and northern East Trenches Areas to the north of South Walnut Creek and Central Avenue Ditch. The hydrogeologic data suggest that ground water discharges either to the surface water of the Woman Creek drainage or to surface water of the South Walnut Creek drainage. It may also continue movement as ground water within the valley fill alluvium of Woman Creek and Walnut Creek drainages.

It appears volatilization adsorption or dilution have reduced VOC concentrations to non detectable levels as alluvial ground water migrates to the east and toward the drainages VOCs have not been detected at well 39 86 (South Walnut Creek drainage) or at wells 67 86 and 66 86 (Woman Creek drainage) located east of the potential sources VOC contamination does not extend farther downgradient than well 41 86 just east of the East Trenches and well 29 87 to the southeast of the 903 Pad Area VOC contamination at these locations is only suspected as VOCs occur at low levels or are otherwise not detected (well 41 86) or the presence of VOCs is uncertain because duplicate samples do not show detectable VOC concentrations (well 29 87) Because VOCs are not migrating in alluvial ground water beyond the facility boundary there is no impact to the public health from those contaminants via this pathway

Ground water samples collected during late 1986 from well 2 71 contained elevated levels of plutonium [32(3) pCi/l] americium [4 4(2 3) pCi/l] uranium 234 [30(3) pCi/l] and uranium 238 [33(5) pCi/l] These are the highest levels of plutonium and americium ever reported for a well at the Plant Therefore an attempt was made to resample the well as soon as these results were available (November 1986) but the well was dry and could not be resampled to verify the reported values The highest plutonium and americium concentrations ever reported for well 2 71 during 1980 1985 were <0 08 pCi/l and $0 16 \pm 0 08$ pCi/l respectively and plutonium and americium concentrations have been within background levels during 1987 The only other ground water data that indicated elevated radionuclides were for 42 86 during late 1986 {U 234 [9 8(1 1) pCi/l] and U 238 [11(1) pCi/l]} and for 40 86 during second quarter 1987 [Am 1(0 73) pCi/l] U 234 10(2) pCi/l] All other ground water samples collected at these wells have not shown radionuclide concentrations above estimated

background levels. It is tentatively concluded that radionuclide contamination of ground water does not exist; however, further sampling and analysis is required for confirmation.

Bedrock ground water is contaminated with VOCs southeast of the 903 Pad Area at wells 11 87BR, 12 87BR, and 14 87BR. Maximum concentrations of VOCs are PCE (43 ug/l), TCE (3 570 ug/l), CCl_4 (560 ug/l), and CHCl_3 (71 ug/l). The downgradient extent of contamination in the ground water of these bedrock sandstones is unknown. However, hydraulic conductivity and gradient data suggest a maximum travel distance of 2250 feet using a maximum calculated gradient of 0.09 ft/ft if the sandstones are continuous. Additional drilling is required to determine the extent and continuity of these sandstones.

9.2.4 Exposure to Contaminated Surface Water

Twenty-six surface water and surface seep samples in the vicinity of the 903 Pad Mound and East Trenches Areas were collected during field activities. Most of these samples were found to contain VOCs. The most contaminated samples appear to be located either just north of the Mound Area and south of the 903 Pad Area. Maximum concentrations of TCE, PCE, 1,1-DCE, CHCl_3 , CCl_4 , and 1,1,1-TCA in the upper South Walnut Creek drainage north of the Mound were 62, 73, 133, 40, 605, and 33 ug/l, respectively. Other VOCs were not detected. Maximum concentrations of TCE, PCE, 1,1-DCE, CHCl_3 , and CCl_4 in the seeps just southeast of the 903 Pad were 40, 65, 140, 84, and 1005 ug/l, respectively. However, the samples collected farther downstream on Woman Creek and South Walnut Creek showed no VOC contamination. For example, no VOCs were detected in surface water samples from the South Interceptor Ditch (Sample SW 30), Pond C 1 (Sample SW 29), Pond B 5 (Sample SW B5).

and South Walnut Creek (sample SW 25) VOCs were also not present in seeps just northwest of Pond C 2 All sampling stations are located downstream of the 903 Pad Mound and East Trenches Areas The VOC contamination of surface water appears to be localized in the immediate vicinity of the 903 Pad and Mound Areas

High plutonium and americium concentrations found in the seeps southeast of the 903 Pad represent particulate forms of these radionuclides originating from contaminated soils at the surface This is concluded because ground water apparently is not contaminated with radionuclides the seeps represent surfacing ground water and the seep samples were not filtered prior to analysis and contained substantial suspended solids As discussed below plutonium contamination of surface soils exists in the vicinity of these seeps It should be noted that none of the surface water samples were filtered which facilitates comparison of the data

Data from stations SW C1 (Pond C 1) SW 29 and SW 28 all located downstream of the 903 Pad on Woman Creek do not show any indication of elevated radionuclide concentrations above background At station SW 25 on South Walnut Creek downstream of its southern tributary (Central Avenue Ditch) 1986 data also do not indicate any elevated radionuclide concentrations above background

It is concluded that any contamination present in surface water near the 903 Pad Mound and East Trenches Areas is removed by natural processes before the water migrates far from these areas No contaminated surface water is leaving the Plant Therefore there is no off site contaminant transport via this pathway and consequently no public health impact from contaminated surface water

93 ENVIRONMENTAL IMPACTS

As discussed in the previous section environmental contamination originating from the 903 Pad Mound and East Trenches Areas appears to be entirely confined to these general areas. This contamination of soils, ground water, and surface water can be considered environmental impacts. Detectable air contamination has not and is not occurring even directly over these areas.

The Areas are not used nor intended for use as public or recreational areas nor for the development of any unique natural resource. No unique ecosystems or endangered species have been observed at the Plant during extensive biological studies. The biota or flora present at these areas does not exhibit obvious stress. For all of these reasons, there are no ecological impacts due to contamination at the 903 Pad Mound and East Trenches Areas.

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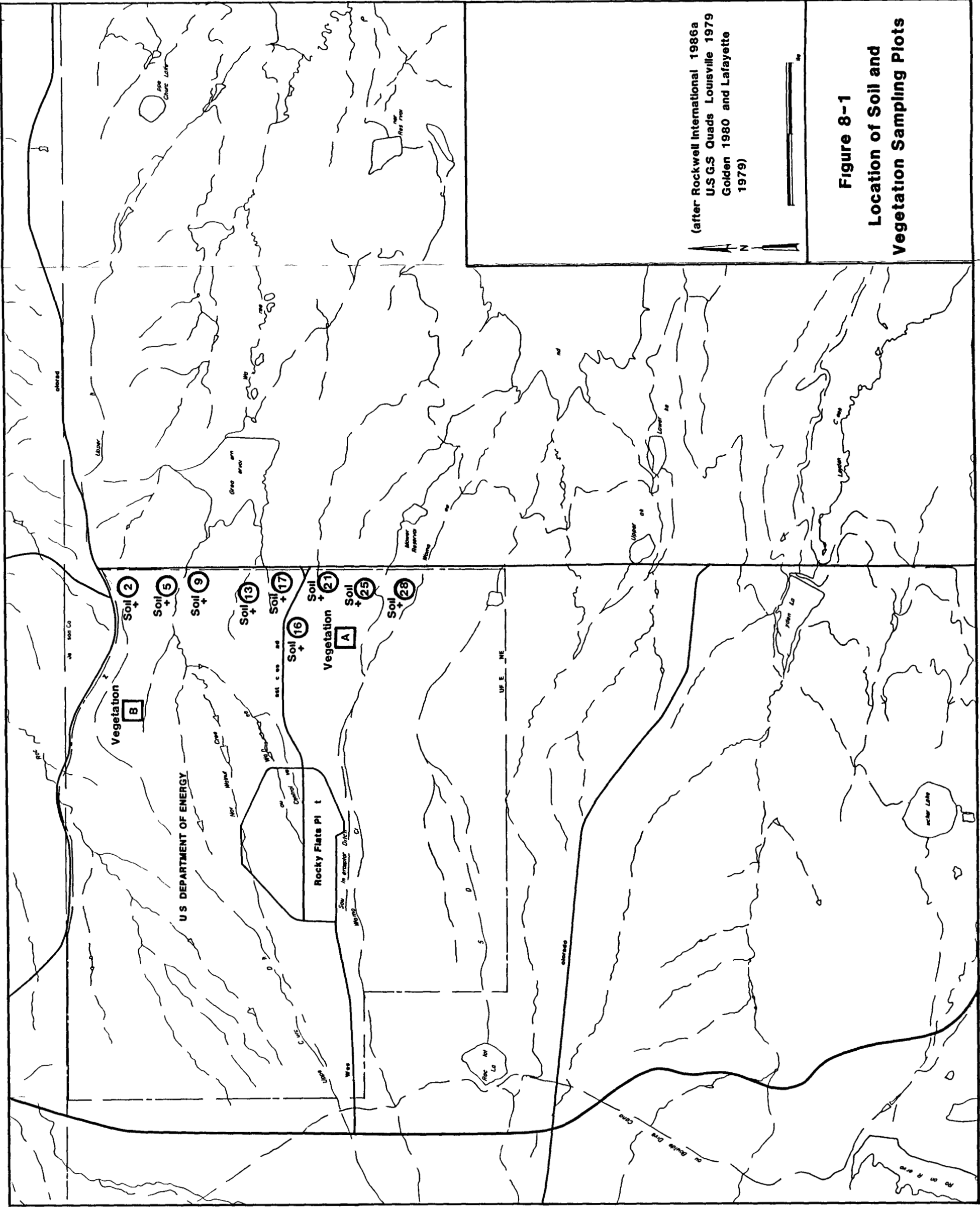
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Figure 8-1
Location of Soil and
Vegetation Sampling Plots